

STUDYNEST | CLASS 11 PHYSICS QUESTION PAPER 1

Chapter 12: Kinetic Theory

Maximum Marks: 40 | Suggested time: 60 minutes

Instructions: Answer all questions. Show calculation steps and units. Original practice paper, not an official examination.

Section A 1-mark questions - $8 \times 1 = 8$ marks

1. What is an ideal gas model? [1]
2. Ideal gas equation? [1]
3. Mean translational kinetic energy? [1]
4. Origin of gas pressure? [1]
5. Monatomic degrees of freedom? [1]
6. Effect of lowering pressure on mean free path? [1]
7. Molar C_v of monatomic gas? [1]
8. Rms speed relation? [1]

Section B 2-mark questions - $6 \times 2 = 12$ marks

9. At fixed T, volume halves: pressure? [2]
10. 27°C in Kelvin? [2]
11. Mean kinetic energy at 300K, $k=1.38 \times 10^{-23}$? [2]
12. Temperature becomes 4T: rms speed factor? [2]
13. Internal energy of n mol monatomic gas? [2]
14. Two main ideal gas assumptions? [2]

Section C 3-mark questions - $4 \times 3 = 12$ marks

15. Rms speed of $M=.028, T=300K, R=8.31$? [3]
16. 1 mol monatomic gas warms 20K, $C_v=3R/2$: ΔU ? [3]
17. At fixed T, pressure triples: volume factor? [3]
18. State equipartition prediction for monatomic gas. [3]

Section D 4-mark questions - $2 \times 4 = 8$ marks

19. Compare rms speeds for molar masses .004 and .016 kg/mol at same T. [4]
20. $f=5, n=2$ mol, $T=300K$: internal energy? [4]

End of question paper.

FORMULA AND EQUATION REFERENCE

Chapter-specific equations and relations

- Ideal gas equation $pV=nRT$; for fixed temperature $pV=\text{constant}$ (Boyle's law).
- Mean translational kinetic energy per molecule = $(3/2)k_B T$.
- Molecular kinetic theory: $pV=(1/3)N m v_{\text{rms}}^2$; hence $v_{\text{rms}}=\sqrt{3RT/M}$.
- For an ideal gas with f active quadratic degrees of freedom: $U=(f/2)nRT$; $\Delta U=(f/2)nR \Delta T$.
- Equipartition: each quadratic degree of freedom contributes $(1/2)k_B T$ per molecule.
- Monatomic molar heat capacity at constant volume $C_v=(3/2)R$.
- Mean free path increases as pressure decreases at fixed temperature, approximately λ proportional to $1/p$.

Use equations only when their assumptions apply; keep units consistent.

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STEP-BY-STEP SOLUTIONS

Concept questions are answered directly; numerical problems show the governing equation and substitution.

Question 1

Principle / definition: Identify the physical quantity or law asked for, then apply the chapter definition.

Apply it here: Negligible molecular volume and forces except during elastic collisions.

Final answer: Negligible molecular volume and forces except during elastic collisions.

Question 2

Principle / definition: Identify the physical quantity or law asked for, then apply the chapter definition.

Apply it here: $pV=nRT$.

Final answer: $pV=nRT$.

Question 3

Principle / definition: Identify the physical quantity or law asked for, then apply the chapter definition.

Apply it here: $3k_{BT}/2$.

Final answer: $3k_{BT}/2$.

Question 4

Principle / definition: Identify the physical quantity or law asked for, then apply the chapter definition.

Apply it here: Molecular momentum transfer to walls.

Final answer: Molecular momentum transfer to walls.

Question 5

Principle / definition: Identify the physical quantity or law asked for, then apply the chapter definition.

Apply it here: Three translational.

Final answer: Three translational.

Question 6

Principle / definition: Identify the physical quantity or law asked for, then apply the chapter definition.

Apply it here: It increases.

Final answer: It increases.

Question 7

Principle / definition: Identify the physical quantity or law asked for, then apply the chapter definition.

Apply it here: $3R/2$.

Final answer: $3R/2$.

Question 8

Principle / definition: Identify the physical quantity or law asked for, then apply the chapter definition.

Apply it here: $\sqrt{3RT/M}$.

Final answer: $\sqrt{3RT/M}$.

Question 9

Working: At fixed T , Boyle's law gives $p_1V_1=p_2V_2$. If $V_2=V_1/2$, then $p_2=2p_1$: pressure doubles.

Final answer: Doubles.

Question 10

Working: $T=27+273.15=300.15$ K, approximately 300 K.

Final answer: About 300 K.

Question 11

Working: Average kinetic energy $= (3/2)k_{BT} = 1.5(1.38 \times 10^{-23})(300) = 6.21 \times 10^{-21}$ J.

Final answer: approx 6.21×10^{-21} J.

Question 12

Working: $v_{rms} = \sqrt{3RT/M}$, so at fixed gas and molar mass v_{rms} proportional to $\sqrt{T}$. If T becomes $4T$, speed is multiplied by $\sqrt{4}=2$.

Final answer: 2.

Question 13

Working: For a monatomic ideal gas $U = (3/2)nRT$. Use the number of moles n and absolute temperature T .

Final answer: $3nRT/2$.

Question 14

Working: Assumption 1: molecules have negligible volume compared with the container. Assumption 2: intermolecular forces are negligible except during brief elastic collisions.

Final answer: Negligible particle volume and negligible intermolecular forces except collisions.

Question 15

Working: $v_{\text{rms}} = \sqrt{3RT/M} = \sqrt{3(8.31)(300)/0.028} = \sqrt{266,785.7} = 516.5 \text{ m/s}$, approximately 517 m/s.

Final answer: approx 517 m/s.

Question 16

Working: $C_v = (3/2)R$. $\Delta U = nC_v \Delta T = 1(1.5)(8.31)(20) = 249.3 \text{ J}$, approximately 249 J.

Final answer: approx 249 J.

Question 17

Working: At fixed T, $pV = \text{constant}$. If pressure triples, $p_2 = 3p_1$, so $V_2 = V_1/3$.

Final answer: One-third.

Question 18

Working: Equipartition assigns $(1/2)k_{\text{BT}}$ to each independent quadratic degree of freedom. A monatomic ideal-gas molecule has 3 translational degrees, so its mean translational energy is $3(1/2)k_{\text{BT}} = 3k_{\text{BT}}/2$.

Final answer: Three translational modes contribute $3k_{\text{BT}}/2$ per molecule.

Question 19

Working: At the same T, v_{rms} is proportional to $1/\sqrt{M}$. The ratio $v_{\text{rms}}(0.004)/v_{\text{rms}}(0.016) = \sqrt{0.016/0.004} = \sqrt{4} = 2$, so the lighter gas is twice as fast.

Final answer: Lighter gas speed is twice as high.

Question 20

Working: $U = (f/2)nRT = (5/2)(2)(8.31)(300) = 24,930 \text{ J}$, approximately 24.9 kJ.

This uses $n=2 \text{ mol}$, giving the corrected total internal energy.

Final answer: $U=24,930 \text{ J}$ approx 24.9 kJ.

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